Air Quality Monitoring:

High Level

Oct 2008 - Apr 2009 ***Final Report***

Overview

The wood waste burner operated by Tolko Forest Products is located within the town limits of High Level. The current study investigates the quality of air in the area with a special focus on particulate matter. Although a wide size range of particles can be emitted by wood burning, the current study focused on concentrations of fine particulate matter (less than 10 micrometer in diameter). The concentration of particulate matter was monitored at one location for five and a half months, beginning in October 2008. In addition, the department's mobile laboratory was used to monitor a suite of gases and particles at various sites in and near the town. This was performed on two days at the start of the study.

Periods of elevated particulate matter concentrations were evident. The data implies that a number of sources may affect the air quality in the town of High Level. This is especially true when meteorological conditions prevent the effective dispersion of pollutants. Such conditions (low wind speeds) persisted for approximately 50% of the sample time. During the sampling period, Alberta's Ambient Air Quality Guidelines for particles less than 2.5 micrometer was exceeded once. The data set was also used to calculate the *air quality index* with respect to particulates. Air quality was rated *Fair* for 70 sample hours and *Poor* for one sample hour. These samples composed 2 percent of the whole data set; thus for the sample period air quality was *Good* 98 percent of the time.

Particulate matter emitted from wood combustion is related to operating temperature; lower temperatures (smouldering) produce more particles. Evidence for impact from the waste wood burner was observed in the form of systematically higher particulate matter concentrations

ISBN No. 978-0-7785-8801-6 (Printed Edition)
ISBN No. 978-0-7785-8802-3 (On-Line Edition)
November 02, 2009

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on Sundays. Higher concentrations on Sundays may have resulted from the restarting of the waste wood burner after routine weekly shut downs.

1 Introduction

Air quality in Alberta is routinely monitored using a network of monitoring stations. In addition, short-term air quality surveys are conducted where there is a lack of, or the need to supplement, air quality information from permanent monitoring stations. In conducting the current survey the department's Mobile Air quality Monitoring Laboratory (MAML) and a stand alone particulate matter monitor were used. The study focused on concentrations of fine particulate matter with the possibility of evaluating the impact of continued use of an industrial waste wood burner on the quality of air in the town of High Level. The waste wood burner is operated by Tolko Forest Products, and is located within the town limits. The burner is operated Monday to Friday 24 hours per day; it is typically shutdown on Friday night and restarted Sunday night. The burner is approximately 30 meters high. The intensity of smoke observed from this burner is reported to vary (Appendix A); this may be due to type of wood, water content of the wood or temperature of the burner. There is a requirement to keep the temperature at the top of the burner at 375 °C or higher 90 percent of the time with some allowance for shutdown and start-up (Code of Practice for Sawmill Plants, 2006).

The size of particles emitted as a result of wood burning can range from a few nanometers to tens of micrometers (μm)[1]; furthermore the amount of particles emitted is dependant on the burning conditions[2]. The larger particles tend to be deposited very close to the emission source, while smaller particles remain suspended in the air and can be transported farther. Very large particles in the form of dust have been noted by town residents; because these particles are visibly present, residents are concerned about their source. However, the focus of this study is the mass concentration of particles less than 2.5 μm also known as $PM_{2.5}$. Larger particles are mostly trapped in the nose and upper respiratory system while $PM_{2.5}$ are small enough to penetrate into the lungs and are associated with health effects.

A standalone continuous particulate sampler *Beta Attenuation Monitor* (model E-BAM) was used to monitor $PM_{2.5}$ concentration within the town of High Level from October 28, 2008 to April 14, 2009. In addition, instrumentation onboard the MAML was used to monitor concentrations at various locations in and near the town at the start of the study. One hour

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[1] For a comparison the human hair is about 70 μm.

[2] Hueglin, Ch; Gaegauf, Ch; Kunzel, S; Burtscher, H. Environmental Science and technology, 1997, 31, 3439-3447.

average concentrations from these samples will be discussed and compared to Alberta Ambient Air Quality Guideline for $PM_{2.5}$ in section 3 of this report.

2 Monitoring Method and Location

A Beta Attenuation Monitor (hereafter referred to as E-BAM) was used to monitor the concentration of particles with aerodynamic diameter less than 2.5 micrometer ($PM_{2.5}$). The E-BAM is a standalone continuous monitor that automatically samples air to determine one-hour average $PM_{2.5}$ concentrations. The instrument was located in a residential area (**Site E** Figure 1a). Daily support for the instrument was provided by a local Albert Environment staff member. The E-BAM collected information on particulate concentration, wind direction, wind speed and temperature for a period of approximately five and a half months (October 28th, 2008 to April 14th, 2009).

In addition to the E-BAM, the department's Mobile Air Monitoring Laboratory (MAML) was used to monitor air quality in the town at the start of the study. The MAML is equipped to measure ammonia, carbon monoxide, hydrocarbons, oxides of nitrogen, ozone, particulate matter, reduced sulphur compounds and sulphur dioxide simultaneously. It provides a "snap shot" of the air quality at a particular time and place. On board the MAML, a GRIMM aerosol technology particulate monitor is used to measure the concentrations of PM_1, $PM_{2.5}$ and PM_{10}. This instrument is able to provide one-minute particulate concentration measurements, from which one-hour averages are calculated.

Air samples were collected at seven sites in and around the town of High Level using the MAML (Figure 1). Daytime sampling was conducted on October 28 and 29th 2008. Furthermore, the MAML was used to monitor overnight particulate matter concentrations and meteorological information at **Site H** (Figure 1a). A description of the MAML and the detection limit of the various instruments onboard is given in Appendix B.

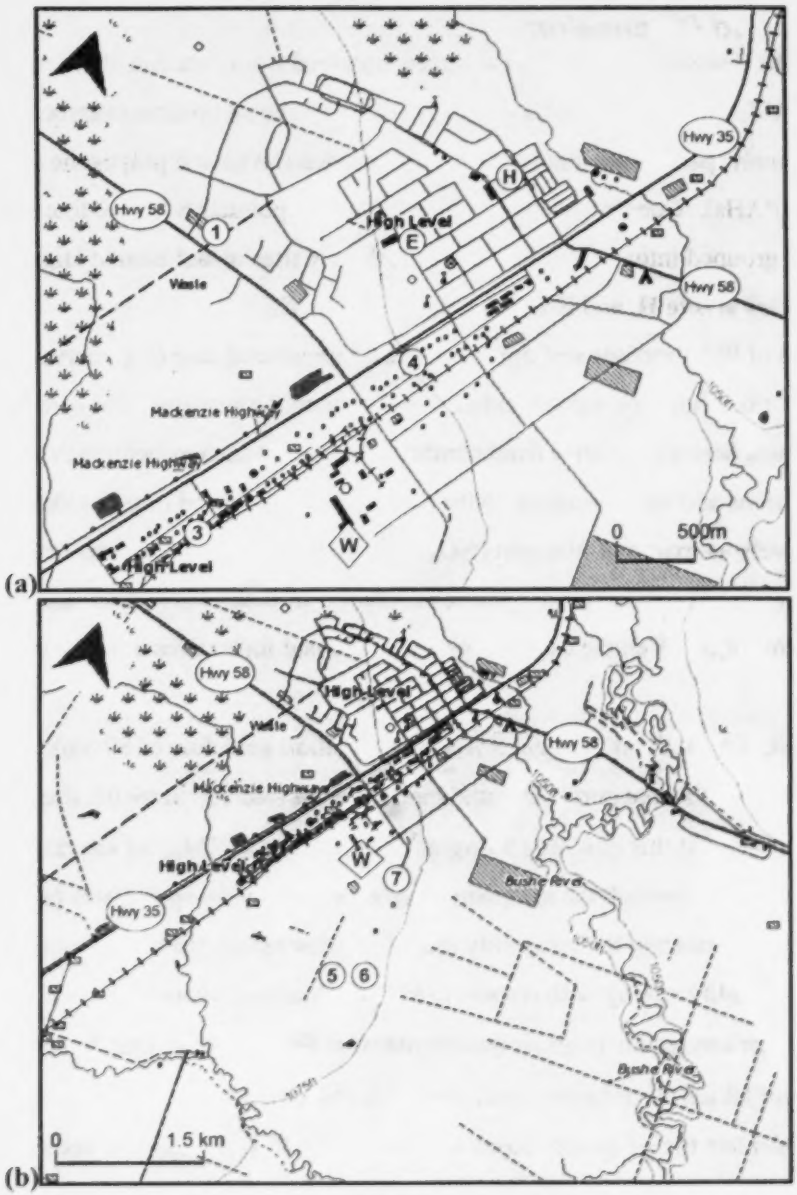

Figure 1: Approximate location of sample sites. The base maps for these figures were obtained from *The Atlas of Canada*[3]. (a) Illustrates the approximate location of sites within the town. E= Location of E-BAM; H= Location of overnight sample site; 1,3 and 4= location of daytime samples sites; W= location of waste wood burner (b) Illustrates the approximate location of sites outside the won of High Level, where sites 5-7 are locations of day time sample sites and W is the location of waste wood burner.

[3] Legend for the base maps can be found at http://atlas.nrcan.gc.ca/site/english/maps/topo/map

3 Results and Discussion

The following sections discuss the results obtained from data collected using the MAML and E-BAMBAM. The result and discussion section focuses on pollutants associated with combustion namely, particulate matter, oxides of nitrogen (NO_x) and polycyclic aromatic hydrocarbons (PAHs). Concentrations of other monitored pollutants can be found in Table A1. The results are grouped into: Daytime samples at the six sites in and around High Level, overnight samples at **Site H,** and E-BAM samples at **Site E**.

Sources of PM_{10} include soil dust, road dust, agricultural dust (e.g., harvest), smoke from forest fires and wood burning, vehicle exhaust and industrial emissions. $PM_{2.5}$ and PM_1 may form in the atmosphere and/or arise from combustion sources such as vehicle exhaust emissions, industrial emissions and wood burning. Nitrogen dioxide (NO_2) and nitric oxide (NO) are known collectively as oxides of nitrogen (NO_x). Motor vehicles, electric utilities and industrial boilers are major sources of NO_x. Polycyclic aromatic hydrocarbons (PAHs) are formed through incomplete combustion. Vehicle exhaust, wood smoke and forest fires are all sources of particle bound PAHs.

Alberta has a one-hour ambient $PM_{2.5}$ concentration guideline of 80 $\mu g/m^3$. This guideline was exceeded once during the study at **Site E** on Dec 16th at 09:05; the one-hour average concentration at this time was 98 $\mu g/m^3$. The impact of $PM_{2.5}$ on air quality can also be evaluated and reported through the air quality index. Typically five pollutants (a minimum of three) are used in calculating the air quality index[4]. In this report, the index is calculated as an indication of air quality ***strictly*** with respect to $PM_{2.5}$. One-hour average $PM_{2.5}$ concentrations of 32 $\mu g/m^3$ or higher can results in an air quality index of *Fair* or *Poor*. One-hour average $PM_{2.5}$ concentrations of 82 $\mu g/m^3$ or higher would result in *Poor* air quality. Data collected at **Site E** were used to calculate the air quality index with respect to $PM_{2.5}$. This data set was used because it was the longest period of record for this study. Air quality index calculated using $PM_{2.5}$ concentrations was rated *Fair* for 70 sample hours and *Poor* for one sample hour. These samples combined composed 2 percent of the data collected.

[4] Information on the air quality index can be found at Alberta Environment's web site.

3.1 Data collected using instrumentation onboard the MAML

Between the evening of October 27th and morning of October 30th, the MAML collected samples at seven sites. At six of the sites (**Sites 1 and 3-7** in Figure 1a and b) samples were collected during the day (08:00-17:00). The complete suite of instrumentation on board was used to collected air quality data during the day. At night, the MAML was parked at **Site H**, when only particulate matter and meteorological data were collected.

3.1.1 Results from Daytime Samples (Sites 1 and 3-7)

Concentrations of NO_x, PAHs and particulate matter measured by instruments onboard the MAML at the various sample sites are presented in Table 1[5]. These one-hour averages indicate elevated particulate matter concentrations in the afternoon of October 28th (shaded area of Table1). The elevated concentrations were observed at a number of sites (**Sites 3-5**) in and just outside High Level (Figure 1a and b). One hour average PM_{10} concentration for the afternoon of October 28th ranged from 33 to 210 $\mu g/m^3$. On average, the $PM_{2.5}$ and PM_1 fraction of PM_{10} were 18% and 8%, respectively. This illustrates that a large fraction of the particles mass was composed of particles greater than 2.5 μm in aerodynamic diameter. In previous studies, similarly elevated particulate concentrations are observed in the presence of road dust and/or emission from a nearby combustion sources. Although elevated, one-hour average $PM_{2.5}$ concentrations did not exceed the Alberta one-hour ambient guideline of 80 $\mu g/m^3$. The maximum one-hour average concentration measured for the afternoon of October 28th was 37 $\mu g/m^3$.

One-hour average concentrations of NO and PAHs observed concurrent to the elevated particulate matter imply that air sampled at these times were most probably impacted by nearby combustion sources. NO is emitted by a wide range of combustions sources, however it is readily converted to NO_2 in the atmosphere. Its relative abundance indicates that the sample is impacted by nearby sources. Furthermore, increases in PAHs concentration implies vehicle exhaust and/or wood smoke as possible sources of particles sampled. Wind speeds during the time of sample were low (< 6 km/hr) producing conditions that limit the dispersion of smoke and/or other pollutants. It is likely, that the observed elevated concentrations on the afternoon of October 28th, have a number of sources including motor vehicle, home heating and possibly waste wood burning from nearby Tolko Forest Products.

Particle concentrations were lower ($PM_{2.5}$ ranging from 4-11 $\mu g/m^3$) for sample periods when the wind speed was about 10 km/hr or higher, thus further supporting that inhibited dispersion of pollutants contributed to elevated particulate concentrations observed in the afternoon of October 28th. However, elevated concentration of NO and PAHs continued to be detected even during conditions that are thought to be conducive to pollutant dispersion. For example, on October 29th at **Site 4**, elevated NO_x and PAHs were noted; particulate matter concentrations were above detection but not substantially elevated (Table 1). At these times westerly winds were consistent. Thus, samples collected at **Site 4** on October 29th were likely impacted by vehicle emissions on Hwy 35 located a few tens of meters west of the sampling site.

On October 29th, moderately elevated particulate concentrations and PAHs were noted at **Site 7** which is located 1.5 km southeast of the waste wood burner. However, NO_x concentrations were among the lowest measured. **Site 7** was surrounded by trees and thus not an ideal sample location (Appendix A). However, samples were collected at this site as there was evidence to suggest that it was downwind of the waste wood burner. Wind speeds during this sample period were low and the MAML operator indicated the presence of smoke odour and wood chips were visible on the vehicle. Examination of the one-minute average particulate matter concentration revealed short term (<1 hr) changes in concentration with peak one-minute average $PM_{2.5}$ and PAHs concentrations of 30 $\mu g/m^3$ and 24 ng/m^3, respectively.

Data collected by the MAML implies that a number of sources may affect the air quality in the town of High Level. This is especially true when meteorological conditions prevent the effective dispersion of pollutants. Data collected at **Site 4** and **Site 7** suggest two possible sources are vehicle emissions, and smoke from the waste wood burner.

[5] Concentrations of all parameters measured by instruments onboard the MAML are presented in Appendix A.

Table 1: One-hour average concentrations of oxides of nitrogen, polycyclic aromatic hydrocarbons and particulate matter as measured by the MAML at the various sample sites.

Date	Start and End Times	Site #	NO PPM	NO_2 PPM	NO_x PPM	PAH ng/m^3	PM_{10} $\mu g/m^3$	$PM_{2.5}$ $\mu g/m^3$	PM_1 $\mu g/m^3$
10/28/08	08:18 to 09:18	1	0.009	0.004	0.012	bd	8	6	4
10/28/08	09:18 to 10:18	1	0.013	0.006	0.019	4	17	8	6
10/28/08	11:25 to 12:25	3	0.013	0.007	0.019	3	83	16	7
10/28/08	12:25 to 13:25	3	0.010	0.007	0.015	4	140	23	9
10/28/08	13:37 to 14:37	4	0.012	0.008	0.017	5	210	37	15
10/28/08	14:58 to 15:58	5	0.003	0.004	0.006	bd	176	31	15
10/28/08	15:58 to 16:58	5	0.001	0.004	0.005	bd	33	9	5
10/29/08	15:18 to 16:18	1	0.003	0.001	0.004	bd	4	4	3
10/29/08	10:34 to 11:34	4	0.017	0.007	0.021	8	6	6	5
10/29/08	11:34 to 12:34	4	0.010	0.009	0.017	7	5	5	4
10/29/08	08:16 to 09:16	6	0.005	0.003	0.007	bd	6	5	4
10/29/08	09:16 to 10:16	6	0.006	0.001	0.006	3	4	4	3
10/29/08	13:09 to 14:09	7	0.004	0.005	0.008	10	17	11	6
10/29/08	14:09 to 15:09	7	0.001	0.005	0.005	7	24	11	6

Notes:

bd – below detection limit **ppm**= parts per million **ng/m^3** = nanograms per cubic meter **$\mu g/m^3$** = micrograms per cubic meter

3.1.2 Results from Overnight Samples (Site H)

Summary statistics for the overnight data are presented in Table 2. These data were collected between the hours of 17:00 to 06:00 the next morning. Data were collected over three nights: October 27/28, 28/29 and 29/30. The median one-hour average concentrations indicate that for the most part particulate concentrations were low. The median one-hour average concentration of 6 $\mu g/m^3$ for $PM_{2.5}$ was well below Alberta's one hour guideline (80$\mu g/m^3$). However, there were periods when elevated concentrations were noted as indicated by the maximum one-hour averages. Wind speed as expected was low during these overnight samples, with median value of 3.5 km/hr (Table 2). Thus, dispersion and transport of emitted pollutants were limited at these times.

To further examine increases in one-hour average particulate matter concentrations, the one-minute averaged data were examined for periods when moderate increase in one-hour average was noted. This examination revealed that there existed noteworthy increases in particle concentrations for periods less than one-hour. Examples are shown in Figure 2 and 3. Results of overnight monitoring revealed two types of events: an increase in sub-micrometer particles (PM_1) as is illustrated in Figure 2, or an increase in $PM_{2.5}$ and substantial increase PM_{10} concentrations as is illustrated in Figure 3. Overnight sampling using the MAML was conducted for only three nights, and each one of these two events was observed once. Thus, there is no

evidence to suggest that similar increases are common in this area. The E-BAM provides one-hour averaged data, thus examination of the 'sub-hour' concentrations of these data is not possible (Section 3.2). Likely sources of particulate matter at these times include home heating, Tolko Forest Products waste wood burner and vehicle emissions. Town residents use natural gas as the primary fuel for residential heating. Tolko Forest Products' waste wood burner was expected to be operational during the sample periods. **Site H** was located about 500 meters from Highway 35 and 58; vehicles idling near the MAML may have impacted the samples. Due to the low wind speeds during these overnight sample periods, the wind direction cannot be used to infer a possible source.

Table 2: Summary statistics for data collected at Site H using instrumentation onboard the MAML. These data are the result of night time samples collected over three nights (between 17:00 to 06:00 on Oct 27/28, 28/29 and 29/30).

Summary Statistics	PM_{10} $\mu g/m^3$	$PM_{2.5}$ $\mu g/m^3$	PM_1 $\mu g/m^3$	Temp °C	RH %	WSP km/hr
Minimum	2	2	1	-3.9	58.4	1.4
25th percentile	5	4	4	-2.4	72.9	2.8
median	7	6	4	-1.7	83.6	3.5
75th percentile	22	11	6	-0.1	89.9	5.7
Max	185	25	19	2.6	94.9	8

Notes:

$\mu g/m^3$ = micrograms per cubic meter **Temp** - Temperature in degrees centigrade **RH** – Relative humidity in percentage **WSP KPH** – Wind speed in Km/hr

Number of data points used in calculations = 37

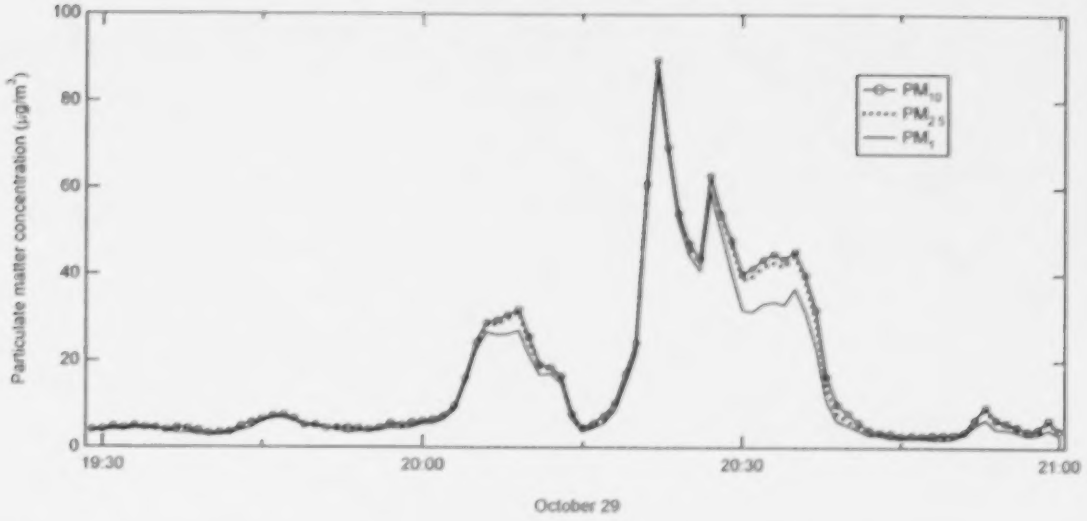

Figure 2: Particulate matter concentrations as monitored by instruments onboard the MAML at Site H on the evening of October 29. Increases in PM_{10} were matched in magnitude by increases in PM_1, indicating that a substantial fraction of PM_{10} were less than one micrometer in aerodynamic diameter.

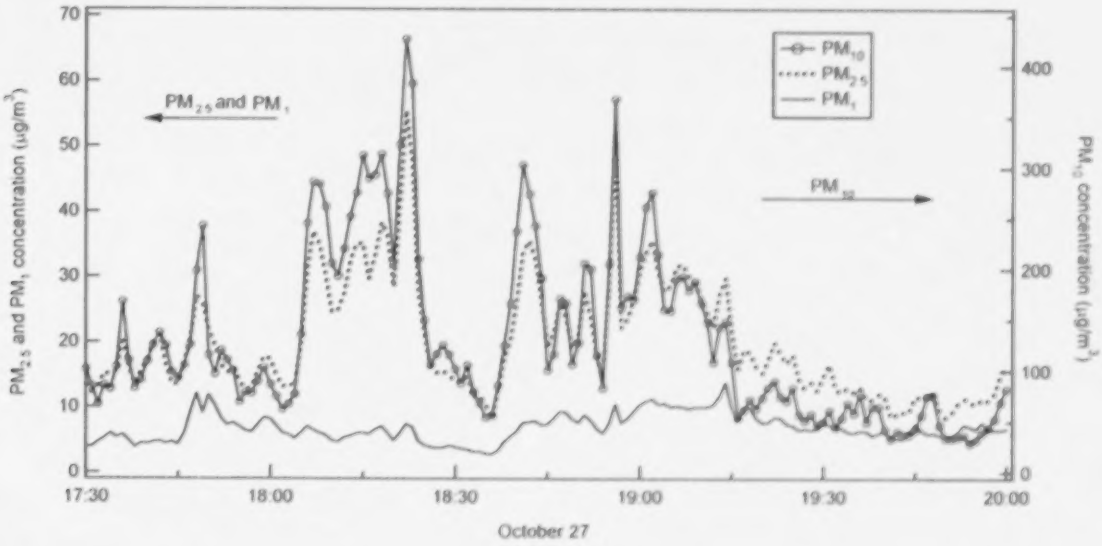

Figure 3: Particulate matter concentrations as monitored by instruments onboard the MAML at Site H on the evening of October 27. Note that the right y-axis indicates concentration for PM_{10} and the left for $PM_{2.5}$ and PM_1. Increases in PM_{10} and $PM_{2.5}$ were not matched by PM_1. For the period shown PM_{10} concentrations were about 6 times higher than $PM_{2.5}$.

3.2 *$PM_{2.5}$ concentrations between October 28th and April 14th as monitoring by E-BAM at Site E*

Summary statistics for the data collected at **Site E** is presented in Table 3. The median $PM_{2.5}$ concentration for the whole data set is 5 $\mu g/m^3$ and is comparable to the median calculated for data collected at other sites using the instrument onboard the MAML. There was one exceedance of the Alberta one-hour $PM_{2.5}$ guideline. Concentrations were generally higher during calm conditions. Figure 4a illustrates the relationship between wind speed and particulate concentration. Wind speeds less than 1.5 km/hr persisted for about 50 percent of the sample time (Figure 4b). It is likely that at these times particulate concentrations at the sample sites had a number of different sources. For periods when the wind was greater than 1.5 km/hr there was no distinct relationship between particulate concentration and wind direction[6]. However, as indicated by the 90th percentile (Table 3), $PM_{2.5}$ concentrations were relatively low for times when the wind speed was greater than 1.5 km/hr.

Table 3: $PM_{2.5}$ concentrations collected at Site E. Summary statistics are calculated for the whole data set, for data collected during calm wind conditions and when the wind speed was greater than 2 km/hr.

Concentration	Units	Whole data set	Calm wind	Wind > 1.5 km/hr
Average	$\mu g/m^3$	7	11	5
25th percentile	$\mu g/m^3$	2	5	0
Median	$\mu g/m^3$	5	8	3
75th percentile	$\mu g/m^3$	9	15	6
90th percentile	$\mu g/m^3$	16	22	10
Maximum	$\mu g/m^3$	98	98	77
Number of data points	count	4053	1513	2540
Greater than 80 $\mu g/m^3$	count	1	1	0

[6] Comparison was only made for periods when the wind speed was great enough (> 1.5 km/hr), times when the wind direction was consistent and meaningful.

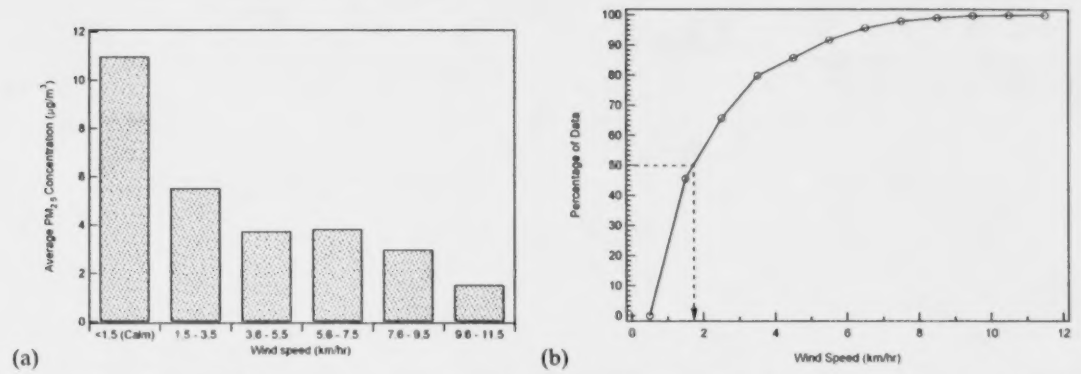

Figure 4: (a) Average $PM_{2.5}$ concentration calculated for various wind speeds. Concentrations were notably higher for calm conditions. (b) Cumulative distribution of wind speed at Site E.

The waste wood burner at Tolko Forest Products was not operating between February 9 and April 17. Thus, the wood burner did not influence the one-hour average $PM_{2.5}$ concentrations at these times. $PM_{2.5}$ concentration collected at **Site E** were separated in to two groups: October 27 to February 9 and February 10 to April 14. 78 percent of the sample hours with concentrations 32 $\mu g/m^3$ or higher (resulting in *Fair* or *Poor* air quality) were observed between October 28 and February 9. However, this may also have been due to colder days[7] at these times. The absence of emissions from the waste wood burner was not clearly evident by simply comparing samples during these two time periods (Table 4).

These data were grouped by day of the week for further analysis. The results are shown in Figure 5. Particulate matter concentrations appear to be systematically higher on Sundays when the waste wood burner was operational (October 28 to February 9 , Figure 5a). This is especially evident when comparing the higher concentrations (75^{th}, 90^{th} percentiles). Particulate matter emitted from wood combustion is related to operating temperature, lower temperatures (smouldering) produce more particles. The waste wood burner operated by Tolko is normally restarted on Sunday night and may take some time to reach ideal operating temperatures. Higher concentration on Sunday may have resulted from the restarting of the waste wood burner. For the period after February 9, higher concentration tended to be observed in the middle of the week.

[7] Lower atmospheric mixing heights due to temperature inversions and increased fuel consumption (home heating and motor vehicle) can lead to higher levels of particulate matter during colder days.

Table 4: $PM_{2.5}$ concentrations as measured at Site E. Waste wood burner was operational between October 28th –February 9th and seized to operate for between February 10th to April 14th.

Concentration	Units	Whole data set	Oct 28th - Feb 9th	Feb 10th - April 14th
Average	$\mu g/m^3$	7	8	6
25th percentile	$\mu g/m^3$	2	2	1
Median	$\mu g/m^3$	5	5	4
75th percentile	$\mu g/m^3$	9	10	8
90th percentile	$\mu g/m^3$	16	18	13
Maximum	$\mu g/m^3$	98	98	64
Number of data points	count	4053	2524	1529
Greater than 32 $\mu g/m^3$	count	71	56	15
Greater than 80 $\mu g/m^3$	count	1	1	0

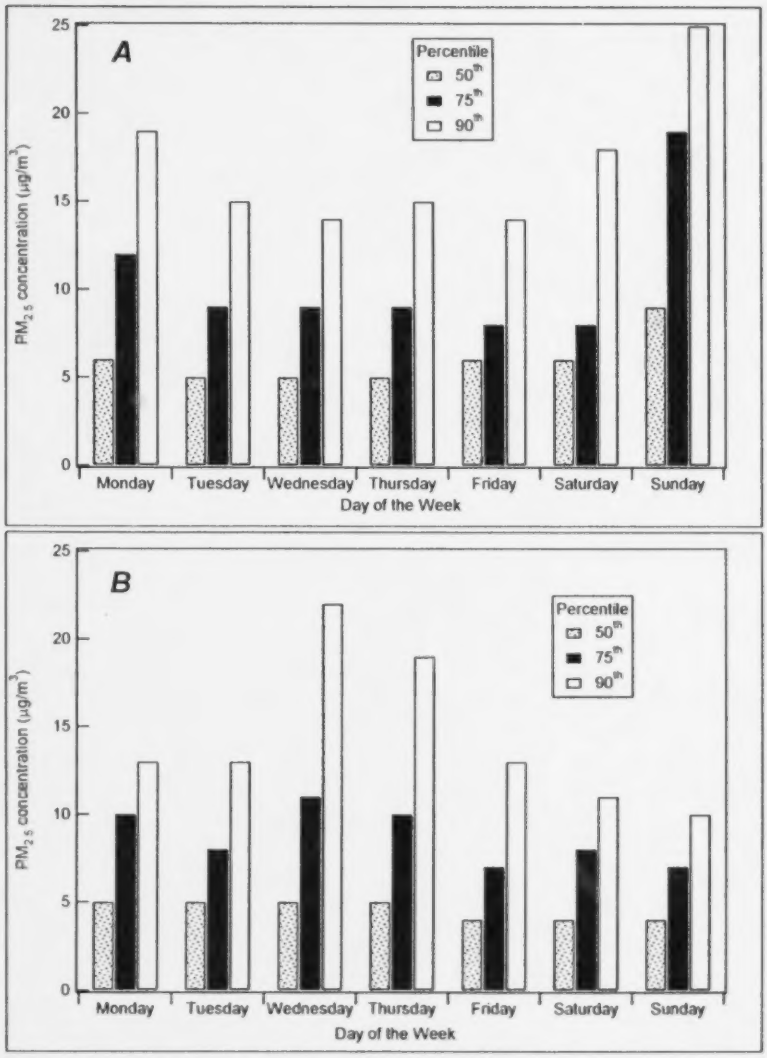

Figure 5: $PM_{2.5}$ concentration measured at Site E, grouped by day of the week. (A) presents data collected between October 27th and February 9th. (B) presents data collected after February 9th at which time the waste wood burner was not operational.

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Appendix A

Table A 1: Ambient concentration for gaseous parameters as measured by the MAML at the various sampling sites. Particulate concentrations are presented in Table 1.

Date	Start/End Times	Site	CO PPM	O_3 PPM	THC PPM	CH_4 PPM	RHC PPM	SO_2 PPM	NO PPM	NO_2 PPM	NO_x PPM	NH_3 PPM	TRS PPM	H_2S PPM
28-Oct	08:18 to 09:18	1	0.4	0.013	3.5	3.3	0.3	bd	0.009	0.004	0.012	0.002	bd	bd
	09:18 to 10:18	1	0.4	0.015	4.2	3.8	0.5	bd	0.013	0.006	0.019	0.003	bd	bd
	11:25 to 12:25	3	0.2	0.016	2.5	2.1	0.4	bd	0.013	0.007	0.019	0.006	bd	bd
	12:25 to 13:25	3	0.2	0.017	2.3	2.1	0.1	bd	0.010	0.007	0.015	0.002	bd	bd
	13:37 to 14:37	4	0.1	0.017	2.1	2.0	0.1	bd	0.012	0.008	0.017	0.002	bd	bd
	14:58 to 15:58	5	0.2	0.019	2.1	2.0	bd	bd	0.003	0.004	0.006	0.001	bd	bd
	15:58 to 16:58	5	0.1	0.015	2.1	2.0	bd	bd	0.001	0.004	0.005	bd	bd	bd
29-Oct	15:18 to 16:18	1	0.1	0.015	2.1	2.1	0.1	0.001	0.003	0.001	0.004	bd	bd	bd
	10:34 to 11:34	4	0.1	0.014	2.0	1.9	bd	bd	0.017	0.007	0.021	0.006	bd	bd
	11:34 to 12:34	4	0.1	0.014	2.1	2.0	0.1	bd	0.010	0.009	0.017	0.003	bd	bd
	08:16 to 09:16	6	bd	0.011	2.2	2.0	bd	bd	0.005	0.003	0.007	bd	bd	bd
	09:16 to 10:16	6	bd	0.015	2.0	2.0	bd	bd	0.006	0.001	0.006	bd	bd	bd
	13:09 to 14:09	7	0.3	0.010	2.3	2.2	0.3	0.001	0.004	0.005	0.008	0.001	bd	bd
	14:09 to 15:09	7	0.2	0.010	2.1	2.2	0.1	bd	0.001	0.005	0.005	bd	bd	bd

Notes:

bd – below detection limit **ppm** - parts per million

Table A 2: Meteorological data as measured by the MAML at the various sample sites

Date	Start/End Times	Site	Temp °C	RH %	WSP km/hr	WDR DEG
28-Oct	08:18 to 09:18	1	-2	80	6	127
	09:18 to 10:18	1	0	74	5	119
	11:25 to 12:25	3	2	65	5	92
	12:25 to 13:25	3	2	63	6	58
	13:37 to 14:37	4	3	60	6	55
	14:58 to 15:58	5	3	62	3	82
	15:58 to 16:58	5	2	69	8	83
29-Oct	15:18 to 16:18	1	0	88	10	270
	10:34 to 11:34	4	-1	90	11	278
	11:34 to 12:34	4	0	88	10	271
	08:16 to 09:16	6	-1	96	9	296
	09:16 to 10:16	6	-1	93	13	293
	13:09 to 14:09	7	0	87	4	287
	14:09 to 15:09	7	1	86	3	291

Notes:

Temp - Temperature in degrees centigrade **RH** – Relative humidity in percentage **WSP** – Wind speed in Km/hr
WDR DEG – Wind direction in degrees

Table A 3: Particulate matter concentration and meteorological data collected at Site H

Date	Start/End Times	Temp	RH	WSP	WDR	PM_{10}	$PM_{2.5}$	PM_{1}
		°C	%	km/hr	DEG	$\mu g/m^3$	$\mu g/m^3$	$\mu g/m^3$
27-Oct	17:26 to 18:00	-0.6	58.4	2.8	116	108	16	6
	18:00 to 19:00	-1.0	60.4	2.6	121	185	25	6
	19:00 to 20:00	-1.5	64.3	2.1	115	87	17	8
	20:00 to 21:00	-1.4	65.3	2.4	115	58	15	9
	21:00 to 22:00	-1.7	67.1	2.2	155	44	11	5
	22:00 to 23:00	-2.4	72.6	1.5	145	56	13	6
28-Oct	00:00 to 01:00	-1.8	68.2	2.2	110	17	7	4
	01:00 to 02:00	-1.6	68.5	2.0	175	18	8	6
	02:00 to 03:00	-2.2	76.9	2.9	302	24	17	11
	03:00 to 04:00	-2.3	78.0	2.6	251	20	14	10
	04:00 to 05:00	-2.0	76.8	1.4	217	17	9	7
	05:00 to 05:44	-3.7	74.2	3.4	271	19	9	7
	18:00 to 19:00	2.6	66.3	3.2	170	19	6	4
	19:00 to 20:00	0.7	75.4	3.2	165	22	6	4
	20:00 to 21:00	0.3	77.9	3.8	124	14	6	5
	21:00 to 22:00	0.0	85.2	3.8	155	4	3	2
	22:00 to 23:00	-0.1	87.8	3.1	166	3	3	3
	23:00 to 00:00	-2.6	72.9	3.0	80	31	13	8
29-Oct	00:00 to 01:00	-0.1	94.2	3.3	148	5	4	4
	01:00 to 02:00	0.4	91.1	7.8	125	5	5	4
	02:00 to 03:00	0.6	87.3	7.5	117	6	5	4
	03:00 to 04:00	0.4	88.5	5.7	128	6	5	4
	04:00 to 05:00	0.4	89.1	5.9	128	7	6	5
	05:00 to 05:52	0.5	86.7	5.2	162	7	5	4
	17:17 to 18:00	-0.9	90.0	8.0	257	5	5	4
	18:00 to 19:00	-1.8	92.3	7.4	250	4	4	3
	19:00 to 20:00	-2.6	94.4	5.9	265	5	5	4
	20:00 to 21:00	-2.7	94.9	4.5	265	22	21	19
	21:00 to 22:00	-1.9	91.4	6.5	255	7	6	5
	22:00 to 23:00	-1.8	92.0	6.9	244	5	5	4
	23:00 to 00:00	-0.3	89.9	3.5	142	4	3	3
30-Oct	01:00 to 02:00	-2.6	89.1	6.8	243	4	3	3
	02:00 to 03:00	-2.7	83.8	4.4	219	3	3	2
	03:00 to 04:00	-3.2	83.6	3.5	223	2	2	2
	04:00 to 05:00	-3.7	80.6	4.1	204	2	2	1
	05:00 to 05:59	-3.9	82.1	4.2	145	2	2	2
	23:00 to 00:00	-2.3	94.9	4.5	228	5	4	4

Notes:

Temp - Temperature in degrees centigrade **RH** – Relative humidity in percentage **WSP** – Wind speed in Km/hr
WDR DEG – Wind direction in degrees $\mu g/m^3$ = micrograms per cubic meter

Figure A 1: Wood waste burner operated by Tolko Forest Products in High Level. Figure illustrates varying amount of smoke emitted from the wood waste burner.

Figure A 2: E-BAM particulate monitor (highlighted) located at Site E

Figure A 3: MAML Site 7, looking in all four directions.

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Appendix B

Alberta's Ambient Air Quality Objectives

Alberta's Ambient Air Quality Objectives[1] are established under Section 14 of the Environmental Protection and Enhancement Act (EPEA R.S.A. 2000, c.E-12, as amended). EPEA provides for the development of environmental objectives for Alberta. The Ambient Air Quality Objectives are used for:

- Reporting on the state of the atmospheric environment in Alberta.
- Reporting to Albertans on the quality of the air through Alberta's Air Quality Index (AQI).
- Establishing approval conditions for regulated industrial facilities.
- Evaluating proposals to construct facilities that will have air emissions.
- Guiding special ambient air quality surveys.
- Assessing compliance near major industrial air emission sources.

Some of Alberta's Ambient Air Quality Objectives are based on odour perception. This is the case for ammonia, nitrogen dioxide and hydrogen sulphide. For these chemicals, people are likely to detect an odour at concentrations well below levels that may affect human health. Alberta's Ambient Air Quality Objectives for one-hour average concentration of pollutants monitored by the MAML are listed in Table B1. Additional objectives can be found on the Alberta Environment's web site or through the department's information centre ((780) 427-2700).

Table B1: Alberta's Ambient Air Quality Objective and guideline measured by the MAML

Pollutant	One-hour AAAQO (ppm)	Basis
Ammonia	2	odour perception
Carbon monoxide	13	oxygen carrying capacity of blood
Nitrogen dioxide	0.212	odour perception
Ozone	0.082	reduction of lung function and effects on vegetation
Hydrogen sulphide	0.01	odour perception
Sulphur dioxide	0.172	pulmonary function
	One-hour AAAQG ($\mu g/m^3$)	
$PM_{2.5}$	80	Canada Wide Standard

ppm - parts per million

[1] *Alberta Ambient Air Quality Objectives*. Alberta Environment. April 2005.

The Mobile Air Monitoring Laboratory (MAML)

The MAML is a 27-foot (8.2 m) vehicle that has been specially designed and equipped to measure air quality. It houses a variety of instruments that continuously sample the air at specified time or distance intervals. The MAML is equipped with:

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- a dual computer system custom-programmed to accept and record the measurement of air samples from each analyser,
- a GPS (Global Positioning System) that identifies the MAML's location as it moves around Alberta,
- an exhaust purifying system that minimizes emissions from the vehicle and
- two on-board generators that are also equipped with exhaust scrubbers

Table B2 lists the pollutants and meteorological data monitored by the MAML. Also indicated are the lower and upper detection limits for each monitored species.

B 1: Alberta Environment's Mobile Air Monitoring Laboratory

Table B2: Pollutants and meteorological data monitoring by the MAML.

Pollutant	Operating Range	
	Lower Detection Limit*	Upper Detection Limit**
Ammonia (NH_3)	0.001 ppm	5 ppm
Ozone (O_3)	0.001 ppm	0.5 ppm
Carbon Monoxide (CO)	0.1 ppm	50 ppm
Hydrocarbons		
Methane (CH_4)	0.1 ppm	20 ppm
Reactive Hydrocarbons (RHC)	0.1 ppm	20 ppm
Total Hydrocarbons (THC)	0.1 ppm	20 ppm
Polycyclic Aromatic Hydrocarbons (PAH)	3 ng/m^3	1000 ng/m^3
Oxides of nitrogen		
Nitrogen dioxide (NO_2)	0.0006 ppm	1 ppm
Nitric Oxide (NO)	0.0006 ppm	1 ppm
Oxides of nitrogen (NO_x)	0.0006 ppm	1 ppm
Particulate Matter		
Total Suspended Particulates (TSP)	1 $\mu g/m^3$	1.0 g/m^3
Particulate Matter <10µm (PM_{10})	1 $\mu g/m^3$	1.0 g/m^3
Particulate Matter <2.5µm ($PM_{2.5}$)	1 $\mu g/m^3$	1.0 g/m^3
Sulphur Compounds		
Hydrogen Sulphide (H_2S)	0.001 ppm	1 ppm
Total Reduced Sulphur (TRS)	0.001 ppm	1 ppm
Sulphur Dioxide (SO_2)	0.001 ppm	2 ppm
Meteorological data		
Wind Speed	0 km/hr	200 km/hr
Wind Direction	0 degrees	360 degrees
Temperature	-40 °C	50 °C
Relative humidity	0%	100%

ppm = parts per million

ng/m^3 = nanograms per cubic meter

$\mu g/m^3$ = micrograms per cubic meter

g/m^3 = grams per cubic meter

* The ***lower detection limit*** indicates the *minimum* amount of pollutant and the lower limit of meteorological data can be measured by the instrument.

** The ***upper detection limit*** indicates the *maximum* amount of pollutant the instrument can detect and the upper limit for meteorological data measured. This limit is set to provide the optimum precision over that range. The upper limit can be raised, however, precision at the lower levels (where most levels are monitored) is then compromised.

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